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MORTALITY AMONG WATERFOWL AROUND GREAT SALT LAKE, UTAH.

(PRELIMINARY REPORT.)

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INTRODUCTION.

It is widely known that in recent years vast numbers of waterfowl frequenting the marshes along the eastern shore of Great Salt Lake, Utah, have died, apparently from disease. Untold thousands of wild ducks, snipe, sandpipers, and other birds of less economic value have perished. Nor is the effect of this mortality confined to the region in question. While countless numbers of waterfowl have perished in comparatively small areas, the effect upon the abundance of these birds in other regions is widespread. In the marshes around Great Salt Lake are bred annually great numbers of waterfowl, and hordes from more northern regions migrate through in spring and fall. These breeding and migrant birds form an important percentage of those migrating or wintering farther south, and serious diminution of their numbers in the affected localities will be felt heavily in other regions. The question of the causes of this mortality and possible measures for its prevention are therefore of widespread interest and importance.

It is to be noted that a similar mortality occurs in other localities, as Tulare and Owens Lakes, Cal., where for several years thousands of birds have perished annually. Reports not yet fully investigated have been received from other districts, and apparently the trouble may occur anywhere in the West under similar conditions.

Early in the investigations a number of dead ducks sent to the Biological Survey were turned over to the Bureau of Animal Industry for examination, the results of which are discussed on another page. Later, agents of that bureau made brief field inquiries into the mortality in Utah. A preliminary examination of the conditions around

NOTE.—This bulletin is a report of progress in investigating the causes of mortality among ducks and other waterfowl in marshes about Great Salt Lake, Utah. It is for the information of sportsmen and others interested in game birds.

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Great Salt Lake was made in the latter part of August, 1913, by S. E. Piper, of the Biological Survey. Following this, the writer began investigations in July, 1914, continuing the work throughout the summer and fall. The present paper discusses the results obtained and may be considered a report of progress. It is planned to continue the investigations during the present year (1915).

HISTORY.

The fact that many ducks were dying around Great Salt Lake was noted in the newspapers in Salt Lake City and Ogden in 1908 or 1909, but the prevalence of a malady among waterfowl was known many years earlier. Fred Hansen, who lives near the mouth of Bear River, says that in October, 1896, two guides brought 400 mallards from Klondike (at the mouth of Bear River), part of which were found dead and the rest alive but helpless. Dr. M. R. Stewart, of Salt Lake City, says that in 1902 or 1903 a few birds died on the New State Gun Club grounds at the mouth of the Jordan River. At the mouth of the Weber River birds were occasionally found helpless in the growths of "bayonet grass" during the fall of 1904, and were the subject of much speculation among the hunters. Early in the season of 1909 a few sick birds were noticed at the mouth of the Jordan River, and in the fall others, thought by some to be crippled birds from the fall shooting, were reported.

About July 15, 1910, sick birds appeared at the mouth of the Jordan River, and shortly after others were found on the Weber. Later, birds were found dying on the great expanse of mud flats and marshes built up in the delta of Bear River. Attention was now fully aroused, and as the mortality among ducks and other waterfowl increased, many theories as to its cause were advanced. The season was exceedingly dry, the water in the marshes was low, and the birds died in enormous numbers, the trouble continuing on Bear River until November. How many wild ducks and other waterfowl perished during that year will never be known. Thousands died both on the Jordan and the Weber, while on the Bear River marshes the mortality was almost incredible. V. T. Davis, in charge of the Bear River Club grounds, estimated that 85 per cent of all ducks on the lake died, and this statement was fully corroborated by others. The stench in South Bay arising from the dead bodies is said to have been unbearable.

Mortality among the birds began again in 1911, but was not so disastrous as during the preceding year. In 1912 few birds died on the New State Gun Club grounds, on the Jordan River, as the marshes were drained and water was not admitted until September 20. Elsewhere, however, conditions were more serious. At this time the trouble was considered contagious, and it was decided to clear the marshes of dead birds. On Bear River 44,462 wild ducks (from the

records of V. T. Davis) were gathered and buried between August 22 and September 21, and about 30,000 birds are said to have been picked up on the Weber River. From the nature of the country this can not represent more than 20 per cent of the total number of birds that died, and probably not more than 10 per cent. Conditions in 1913 were somewhat improved, but still great numbers died. During the past year fewer birds perished, though the mortality was great enough to cause alarm.

In the southern San Joaquin Valley, Cal., many birds have died on Soleta, Goose, Buena Vista, and Tulare Lakes since 1909. At present the two lakes first named are dry and the third contains an abundance of fresh water. On Tulare Lake, however, conditions are unchanged. In November, 1914, it was estimated by Tipton Matthews, deputy game warden of Kern County, and the writer that at least 15,000 birds had perished there during the preceding summer. Mr. Matthews stated that he has known of sick birds around Goose Lake and at Browns Knolls (Widgeon Gun Club grounds) for at least 20 years when the water was low in summer. Goose Lake is now dry, and as the water at Browns Knolls is kept fresh by artesian wells there is little trouble.

In June, 1891, Dr. A. K. Fisher, of the Biological Survey, noted large numbers of eared grebes and spoonbills dead around the shore of Owens Lake, Cal., and estimated the number of dead grebes at 35,000.[1] From the 12th to the 14th of November, 1914, the writer found many dead birds of these same species in this locality, and he was informed that this was an annual occurrence.

TERRITORY COVERED IN INVESTIGATIONS.

On July 12, 1914, work was begun in the Salt Lake Basin and continued until October 30. Investigations were made at the mouths of the Jordan, Weber, and Bear Rivers, the main areas affected (see Pls. I and III). Because of the large area involved, diversified conditions, and convenience of access to the marshes, most of the experimental work was carried on at the mouth of Bear River. In addition to the localities mentioned, conditions were studied at Willard Spur, Promontory Point on Great Salt Lake, and Locomotive Springs near Kelton.

From November 3 to 11 Tulare Lake, in California, was visited, in order to investigate the mortality in that region, and conditions at Owens Lake in the same State were studied from November 12 to 14.

At the mouth of Bear River, in Utah, quarters were furnished at the Duckville Gun Club, and thanks are due the officers and members of the club for assistance and facilities extended. Much assistance was rendered by A. P. Bigelow, of Ogden, and L. B. McCornick, of

[1] North American Fauna No. 7, 1893, p. 12-13.

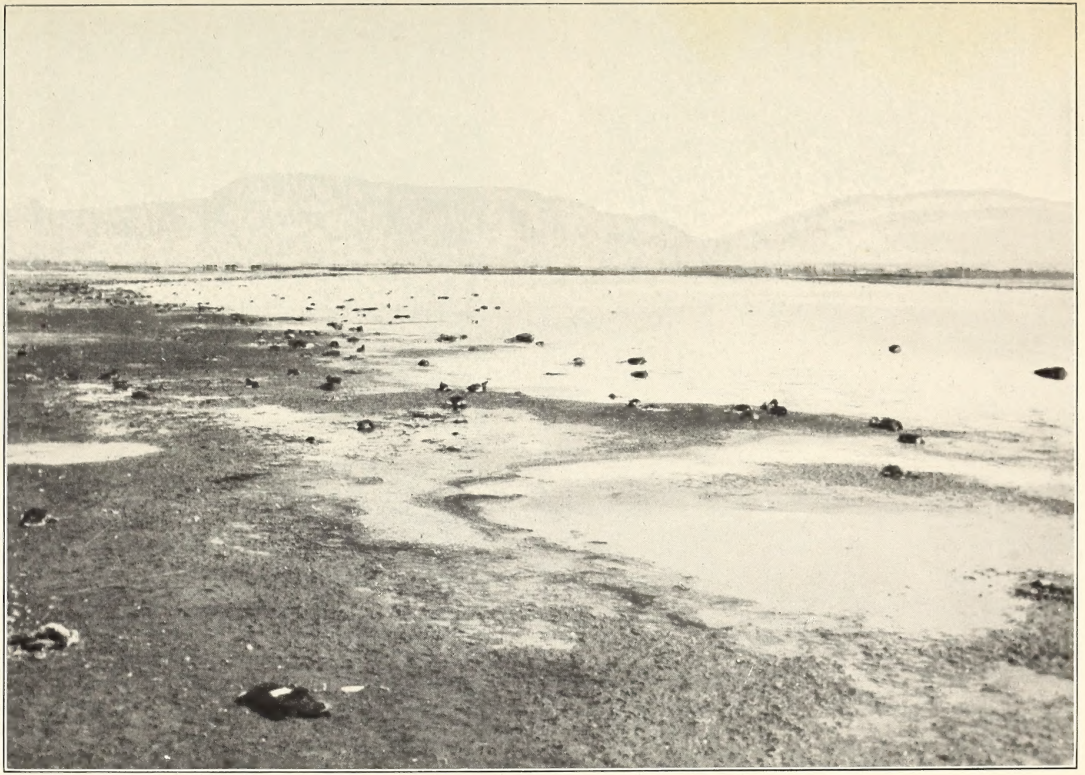
Salt Lake City, who were deeply interested in the work. Valuable information was obtained also from V. T. Davis, in charge of the grounds of the Bear River Club. At the mouth of the Weber River, W. O. Belnap gave all possible assistance, as did other members of the North Shore Gun Club. At the mouth of the Jordan River work was done at the New State Gun Club. Permits for shooting such birds as were necessary for purposes of investigation were granted by the State fish and game commissioner, Fred W. Chambers. In California the State fish and game commission furnished an assistant, Tipton Matthews, deputy warden of Kern County, whose aid rendered the work around Tulare Lake effective.

NATURE OF THE TROUBLE.

During the season's work in Utah 27 species of birds of 11 families were found to be affected. Among these were 9 species of ducks, 10 of shorebirds, and 8 miscellaneous forms ranging from grebes and snowy herons (see Pl. III, fig. 1) to the pipit. Among ducks the pintail and green-winged teal seemed to be most susceptible, while the mallard, spoonbill, and cinnamon teal followed them closely. Avocets and stilts suffered more heavily than any other shorebirds.

The birds affected first lose the power of flight and are unable to rise in the air, though in some cases they can flutter across the water, and in others can fly for a few rods before dropping back. The legs next become affected and the power of diving is lost. As the birds grow weaker, they crawl out on the mud bars, if able to do so, or hide in growths of grass or rushes. In a later stage of the affection they are unable to rise. Finally the neck relaxes and the head lies prostrate (see Pl. II, figs. 1 and 2). If in the water, death comes by drowning, but on land, birds may live for two days or more in this condition.

A large series of postmortem examinations revealed no pathological lesions other than that the intestine was reddened and firm and hard to the touch. When the gut was slit, washed, and examined under a low magnification, the capillaries in the intestinal villi were found to be distended, showing intense irritation. The reddening of the canal appeared sometimes in spots, most severe at the bends of the intestine, but at others it extended continuously from the duodenal loop to the cæca. Clots of extravasated blood, partially digested, were found in most cases, and not uncommonly the cæca were distended with this matter. A severe dysentery occasioned by the irritation of the intestine was the obvious external symptom. The feces were greenish and stained the feathers about the anus and sometimes well up on the abdomen. Large quantities of renal matter were present, white and almost solid, and with an offensive odor. As the food residue in the intestine worked off, this renal matter constituted an increasing proportion of the feces, frequently solidifying



DUCKS DEAD FROM THE SO-CALLED "DUCK MALADY."

Helpless birds may be seen in the foreground. Photograph taken at mouth of Weber River, Utah, September 14, 1914.

FIG. 1.—TWO MALLARDS, ONE HELPLESS, THE OTHER DEAD.
Photograph taken at mouth of Bear River, Utah.

FIG. 2.—A SICK MALLARD.
The head has fallen on the back; otherwise the bird would have drowned. This bird recovered when given fresh water.

FIG. 1.—SNOWY HERONS DEAD FROM THE SO-CALLED "DUCK MALADY."
Photograph taken September 22, 1914, at mouth of Bear River, Utah.

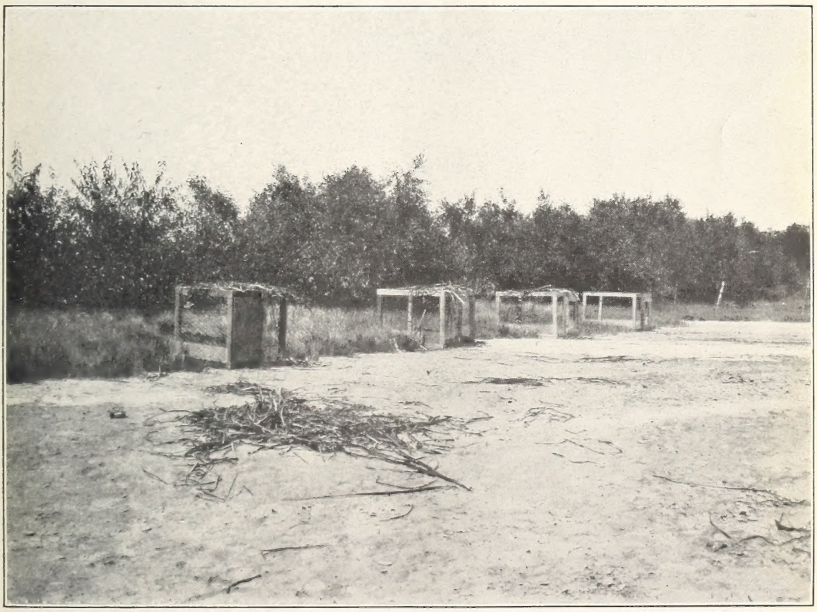


FIG. 2.—ROW OF EXPERIMENT PENS AT MOUTH OF BEAR RIVER, UTAH.
In these inclosures ducks were kept under experimental conditions. Similar pens were stationed at other localities on the mud flats.

into a chalky mass which closed the anal opening. In about one-third of the birds kept under observation a secondary trouble developed in the course of two days or more after they lost the power of flight. A watery exudate came from the eyes and nasal chamber, and through the internal nares ran into the throat. This occasioned trouble in breathing. At times the discharge thickened into a whitish, cheesy mass and cemented the eyelids together.

THEORIES AS TO CAUSE.

Many theories have been advanced to account for the mortality. It has been variously ascribed to bacterial infection, typhoid infection from the presence of sewage, parasitic nematodes, poisoning from the deposition of sulphur or arsenic from smelters, and waste water from sugar factories. Other minor hypotheses need not be noted.

BACTERIAL INFECTION.

The fact that so many species of birds are affected militates against the theory of bacterial infection, and no bacillus apparently capable of transmitting the trouble has been isolated. Dr. J. R. Mohler, of the Bureau of Animal Industry, writes as follows concerning the ducks examined in that bureau:

> Relative to our investigations concerning the cause of death of large numbers of ducks in Utah, the information at hand points to the probability that death is due to an acute poisoning, and not to a disease of bacterial origin. The suggestion has frequently been made in the past that the water which the ducks drink is poisoned by the discharge of sulphuric acid, arsenic, copper, and other materials from smelters. A duck in captivity can be easily poisoned by administering any of these substances; but it is very doubtful whether a large body of running water in which large numbers of ducks in flight could obtain water could be poisoned even if a large chemical works discharged its entire output into the stream. Dilute sulphuric acid in small amounts is harmless, and it is doubtful whether ducks would drink a solution of sulphuric acid of any appreciable strength because of the sour taste. Estimations were made of the amounts of sulphates, sulphuric acid, arsenic, and copper in the stomach contents and tissues of ducks from Utah. In no case did the results obtained point to any of these substances as the probable cause of death. Small amounts of sulphates, arsenic, and copper can be found in the tissues of any animal, and are no indication of abnormal conditions.
>
> Practically all the live ducks forwarded to Washington for study promptly recovered, while the dead ducks received were autopsied, but failed to show lesions of diagnostic value. Numerous inoculations were made from the different organs of the ducks, both on culture media and into experimental animals, but up to the present no special organism has been found which might be regarded as the causative agent of the disease. The earlier incrimination of the coccidia found in the intestinal canal of a number of ducks, as the exciting factors of the disease, has not been substantiated by later investigations.

PARASITIC NEMATODES.

Microscopic examinations in the field of a large number of blood smears failed to reveal the presence of nematodes, and a collection of material from the feeding grounds of the ducks near the mouth of the

Weber River was forwarded to the department for study. This was critically examined by Dr. N. A. Cobb, of the Bureau of Plant Industry, a leading authority on nematodes, who reports as follows:

A preliminary examination of the nematodes collected from material from the Weber River, Utah, does not disclose any reason for supposing any of the nematodes found could be connected with the great mortality noticed among wild ducks feeding in the locality whence I understand this material comes. A single specimen has been seen which is of a doubtful character and may perhaps be connected with some parasitic nematode form. This specimen, however, is of small importance, considering the large number of specimens that have been so far looked over. I think it is quite safe to assume that nothing in the way of an explanation of the mortality of the ducks will come as a result of these examinations.

SMELTER AND FACTORY WASTE.

Sulphur poisoning has been held by many to be at the root of the trouble, but the presence of ducks and other birds in California apparently suffering from the same disorder, in localities where there is no appreciable trade waste of sulphur, is sufficient to disprove this theory. Birds kept under experimental conditions were given various solutions of sulphuric acid, but they failed to show symptoms similar to those exhibited in nature. None of the changes incident to death from arsenical poison were found in the internal organs of the large number of birds examined.

In regard to waste water from sugar factories on the Weber River, high water in the fall of 1914 came down in mid-September, carrying with it drainage from the settling ponds of the sugar factory, and though the toxic matter present was sufficient to kill large numbers of carp and chubs, conditions among the ducks improved immediately with the rush of water to the flats.

AN ALKALINE POISON AS THE CAUSE.

While it is not yet possible to set aside all these theories as groundless, it is believed that further investigations will disclose a poison as the real cause of the trouble. The work of the past summer leads to the conclusion that the mortality results from an alkaline poison, the exact nature of which is still to be determined. That this is the case appears from several facts.

As formerly stated, no lesions were present in any of the organs of the many birds examined, other than a severe irritation in the lumen of the intestine. Practically all the birds affected are fat, even though found helpless or dead; not until they begin to recover do they get thin. In birds relatively strong the kidneys make a vigorous effort to throw off the matter absorbed through the intestines, and thus the excretion of renal matter is greatly increased and is given off in almost solid form.

It is well known that a large percentage of the afflicted birds recover if they are given fresh water. During the investigations at the mouth of Bear River, 586 sick ducks of 6 species were taken from the flats and placed in pens at the Duckville Gun Club, where there was running water from Bear River. Of this number, 426 birds, or 73 per cent (see p. 9), entirely recovered. Had the cause of the trouble been bacterial infection, such a recovery would not have been possible. The large assortment of species of birds affected, ranging from grebes, ducks, gulls, shorebirds, and snowy herons to an occasional land bird, is in itself an argument against the disease theory and points unmistakably to the conclusion that a poison is the real cause. Diseases which are fatal to even closely allied species are not common, and one involving many species among birds belonging to several different orders is unknown.

The fact that a similar mortality occurs in California also goes to prove that the trouble is due to a salt or an alkali. In a careful study of local conditions there, it was possible to establish this similarity and to check doubtful points encountered in the Utah work.

Around Great Salt Lake the birds undoubtedly sicken in the shallow water bordering the mud flats. As these flats dry after high water, salts and alkalis crystallize on the surface of the ground. When light rains form pools on the flats, or when a steady wind blows the water across the dry barrens, pintails, green-winged teal, and other waterfowl follow, eager to feed on the newly flooded lands. As the highly soluble salts are taken up by the water from the previously dry surface, the birds feeding here sicken and die in large numbers. Every unusual outbreak on Bear River during the past summer was found to correspond with some such phenomenon. In other localities, as the mouth of the Weber, the poorly drained pools contain a solution concentrated by evaporation. As soon as irrigation ceases and there is a great increase in the amount of water coming down the river the constant flow steadily drains the flats, removing the stagnant water, and the mortality ceases almost at once.

At Tulare Lake, Cal., it may be found that the mortality will increase when the water is blown out by the wind to cover new ground. During the summer of 1914 large areas along the south shore of the lake were flooded before wheat planted there was ready to harvest, and on these flats were found great numbers of ducks and other birds dead.

Birds resident on Bear River undoubtedly establish a certain degree of immunity from the mortality. In spring when migrants first return from the south it is said that a few sick birds may be found along the overflows. Later these disappear and few of the breeding individuals are markedly affected until mid-July. It is certain, however, that water harmless to these individuals is highly toxic to

migrants gathering from near-by breeding grounds to feed, molt, and pass the early fall in the accustomed security of the great marshes. Large numbers of the birds found dead in July and August undoubtedly have come to these marshes from other localities. In the brief account given of the history of the trouble it was shown that sick birds have occurred for a longer time than is commonly believed. In fact there can be little doubt that for many years under certain conditions a few sick birds have been present annually in alkaline pools and on mud flats bordering the mouths of the rivers. The sudden increase in the mortality may be explained by the increased amount of water used for irrigating purposes. Undoubtedly the quantity of water reaching the lake through the rivers has been greatly reduced within the past 15 years. Alkalis and salts are leached from the soil by irrigation and carried off in the drainage to be deposited in the deltas of the rivers and elsewhere. An instance of this leaching is shown in the freshening of the ground water north of Bear River near Corinne. Under these changing conditions disaster came with the dry summer of 1910.

SUGGESTED REMEDIES.

Fresh water is the only remedial agency yet discovered for dealing with this mortality among waterfowl. In the marshes at the mouth of the Jordan River the problem may be considered as settled. Water from the Jordan is carried through the marsh in a series of canals, and as long as it is abundant these are kept full. When the supply fails, as it may in dry years, the marsh can readily be drained and dried. Under normal conditions there are only two points in these channels where stagnation and consequent mortality may occur to any extent; namely, near the Mallard Holes and about the Duck Puddles on the west side. On the flats below the dams on the lake front a small number of birds will undoubtedly die, even though the marshes are drained, but under present conditions this can not be remedied.

At the mouth of the Weber River the situation is more difficult. Here the north channel at present marks the true course of the stream, though in late summer there is little water, as the whole supply is diverted near Ogden for irrigation purposes. Toward the lake are level flats with shallow pools of water connected by a very slight current, or cut off in places from the main body. The south channel has higher banks and runs as a narrow stream supplied by waste water from irrigation ditches. Few, if any, sick birds occur in this channel, as it is deeper and well drained. However, the ducks elect to use the shallow flats along the north channel, and probably less than 10 per cent of the birds that gather there during the summer are alive by the opening of the shooting season on October 1. If the

lower course of this north channel from the North Shore Gun Club eastward can be ditched and the water prevented from spreading on the shallows, as it does now, conditions will undoubtedly improve. This should cause the ducks to use the better drained south channel and alleviate the trouble. When the irrigation dams are opened in September and there is an abundance of water, the flats could again be covered, attracting the birds for the fall shooting. Here it might be possible also to establish ponds fed by artesian water which would save many birds could they be induced to visit them to feed and drink.

The extensive flats at the mouth of the Bear River present a still more serious problem. So large an area is involved that drainage under present conditions is impracticable, but even if it were possible this course would deprive enormous numbers of water birds of a summer home. Apparently the only solution here is to increase by some means the water supply during July, August, and the early part of September. If an agreement could be made with the canal companies controlling the irrigation project dams across Bear River whereby more water could be allowed to pass their dams, reservoirs might be established higher up, and a supply might be reserved for the summer months. It might even be practicable to utilize for this purpose some of the water from Bear Lake. The construction of a low dam across South Bay and East Pass in order to raise the water level has been considered. As such a dam would be cut out each year by the ice, an endeavor to increase the water supply would be more practicable. In damming up the bay there is danger of too much stagnant water, and this might add to the trouble.

A measure which might be adopted in all three localities, and one strongly recommended, is to station men on the marshes to gather up the helpless birds and pen them on fresh water. Considering the great number of birds that might be saved in this way the expense will be slight, and in dry seasons this may prove the only feasible means of relief. From August 11 to September 26 there were brought in to the Duckville Gun Club 586 ducks, of 6 species. The following table gives the percentage of recoveries and deaths:

Species.	Number.	Recovered.	Died.
		Per cent.	*Per cent.*
Mallard	59	80	20
Gadwall	5	80	20
Pintail	233	77	23
Green-winged teal	258	69	31
Cinnamon teal	16	63	37
Spoonbill	15	60	40
Total	586	73	27

When large and small ducks were inclosed together the stronger pintails and mallards crowded the teal and spoonbills, and many were

drowned. It also developed that very weak birds should be separated from the others. Under more favorable conditions the percentage of recoveries could be markedly increased. California sportsmen will be interested to know that at present this appears to be the only measure that will prove successful on Tulare Lake. It is even possible that birds once cured may become to a greater or less extent immune, and will not readily be affected again.

In order to obtain data on this possible immunity and on the subsequent longevity of birds which have recovered from the poisoning, aluminum bands were placed upon the legs of 270 of the birds released during the past summer. Each band bears a number on one side and on the reverse the inscription "Notify U. S. Dept. Agr., Wash., D. C." By this means the birds may be identified should any of them be found or captured.[1] Already reports have been received concerning more than 20 of these birds. Should more of these bands be secured it is hoped they will be forwarded to the Department of Agriculture with full information as to date taken and attending circumstances.

[1] Valuable information in another line of investigation will be forthcoming from these bands. At present knowledge of the routes of migration followed by waterfowl is based upon observation as to the dates of arrival or departure of the birds in various localities. These, properly tabulated, show the movement of the species in question as a whole. The actual lines of flight pursued by individual birds are almost entirely unknown. The importance of information on this point can not be overestimated.

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